Developing Gaze-based Map Interactions in Mixed Reality Devices

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The eye-tracking technology allows recording the position and movements of a person's gaze. In the cartographic field, it has been used for evaluating map designs [1], gaze-history visualisation [2], and interaction purposes [3]. In a few approaches, the interaction with cartographic interfaces has utilised gaze as input [2], such as zooming and panning [3]. Previous research has shown that gaze-supported interaction can contribute to cartographic applications. The hardware used for the gaze-based interactions varies [4]. However, research is missing on how alternative human-computer inputs like hand gestures in a mixed reality environment can be substituted by eye-tracking for user-map interactions. This research aims to develop gaze-based interactions to facilitate user-map interaction in the MR environment.

Objectives

1. Identify and determine cartographic interactions for the gaze control in the MR
2. Assemble a subset of MR interfaces for the selected interactions
3. Evaluate the performance and user experience of assembled interfaces

Research Approach

The research combines experimental and cross-sectional designs. The experiment implies different users interacting with maps in using MR application. The interactions developed for this research are selected from the fundamental cartographic, gaze-based, and MR interactions. Along with the gaze-based interface, conventional and gaze-aware (mixed) interfaces are assembled in the application for evaluation purposes. The cross-sectional design implies conducting survey to evaluate the interfaces from the performance and user experience perspective. The task-based approach is used to gain data for the evaluation as one of the standard approaches.

Case Study

The assembled application contains three interfaces:

- eyes-controlled as the gaze-based interface (1) (Fig.1)

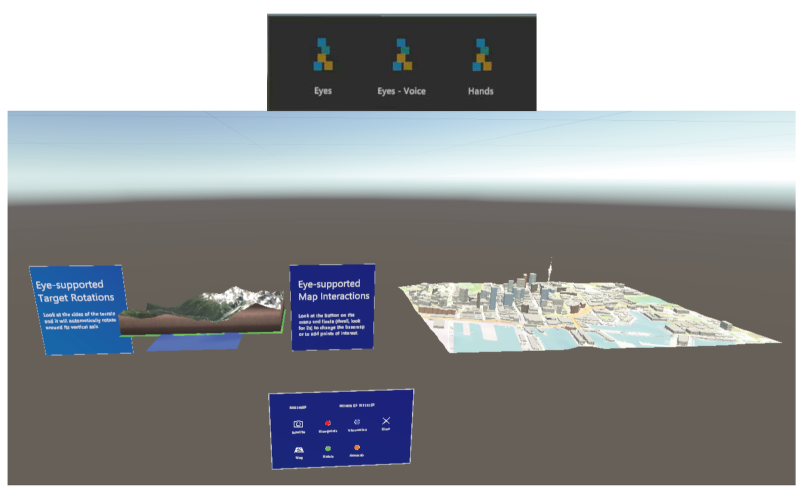

Fig.1 Gaze-based interface scene: interface menu, terrain, city model, and overlay menu

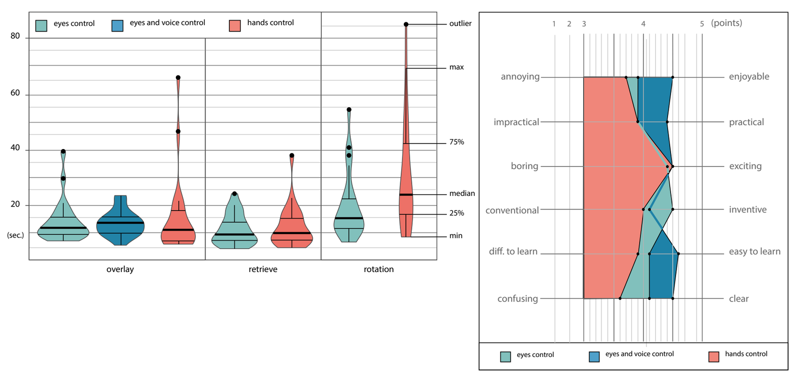

Fig.2 Measured performance results (left) and the user experience (right)

- eyes-voice controlled as the gaze-aware interface (2)
- hands-controlled as the conventional interface (3)

Each interface is used to test the overlay and retrieve interactions. Eyes-controlled and hands-controlled interfaces have the rotation interaction additionally. Two 3D map models are created for the selected interactions. The first model is the terrain that can be rotated horizontally: by gazing at the sides of the model (1), by directing the hand-ray, pinching, and moving the hand (3). The second map is the city model that contains base maps, buildings, and points of interest. The user can retrieve the names of buildings by gazing at the building (1,2) or directing the hand-ray at it (3). Using the overlay menu, the user can change the base map from satellite view to street map and add points of interest such as hotels, artwork, etc. That can be performed by either gazing and dwelling at the selected menu button (1), or by saying the name of the button out loud (2), or by air-pressing it with the index finger (3).

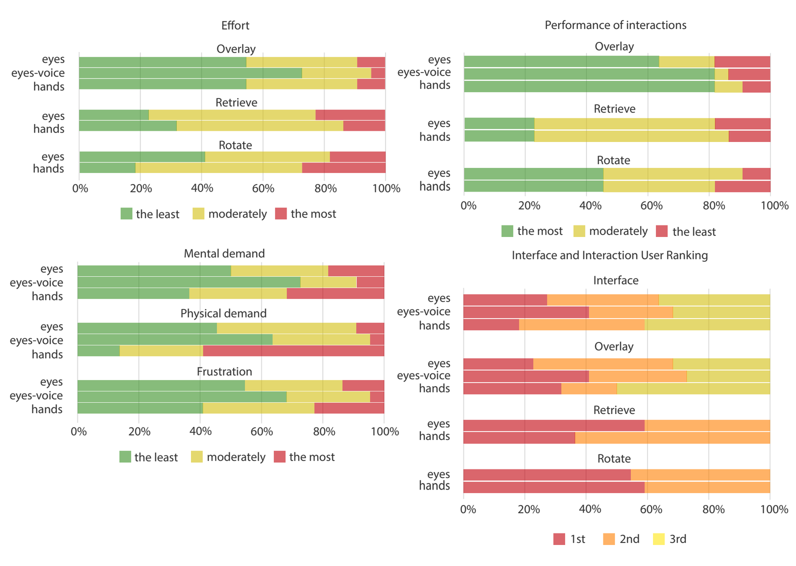

Fig.3 Results of user experience ranking of interfaces and interactions

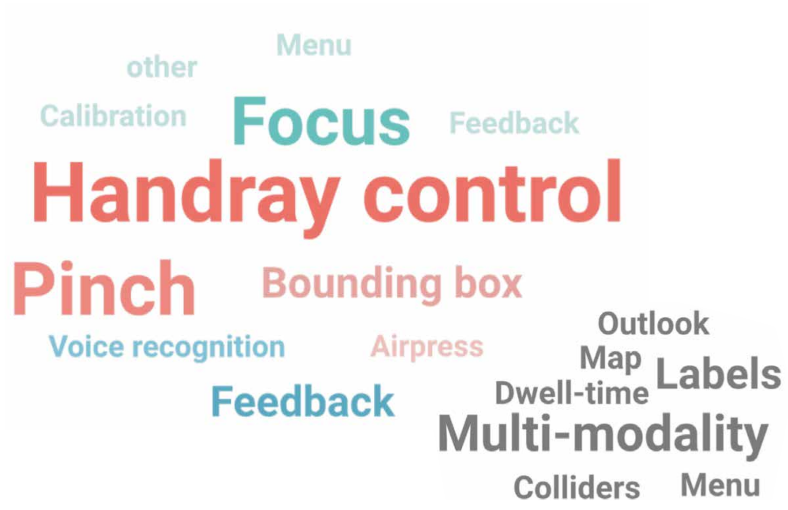

Fig.4 Difficulties encountered with eyes- (green), hands- (red), and eyes-voice (blue) interfaces and suggestions (grey)

During the user study participants went through the consequent stages: filling the background information questionnaire; testing the application and performing interaction tasks; filling the user experience, task load, and interface ranking questionnaires.

Conclusion

In this research, gaze-based user-map interactions are developed and evaluated. The retrieve and rotate tasks are performed the fastest when using gaze as a controller (Fig.2). However, the overlay interaction performance with the eyes-controlled interface is lower than with the voice-controlled.

The gaze-based interface (Fig.3) is considered the most inventive interface within the three assembled interfaces. In addition, it is evaluated as more enjoyable, easier to learn, and less confusing than the conventional hands-controlled interface. Nonetheless, the gaze-based interface is inferior to the gaze-aware interface in the same qualities. Moreover, the gaze-based interface is evaluated as requiring more mental and physical demand and effort than the gaze-aware interface; however, less than the conventional interface requires.

The most problematic interface, according to the survey results, is the conventional interface (Fig.4). However, the gaze-based interface has also presented some difficulties for the users, such as focusing on the target due to accuracy in the position of the gaze-pointer, or insufficient dwell time, or the incomplete map design.

Future research can be directed to improving the usability of gaze-based user-map interactions. The multimodality, as suggested by the users (Fig.4), can be explored for gaze-based interactions.

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